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(54) **OPTICAL IMAGING SYSTEM**

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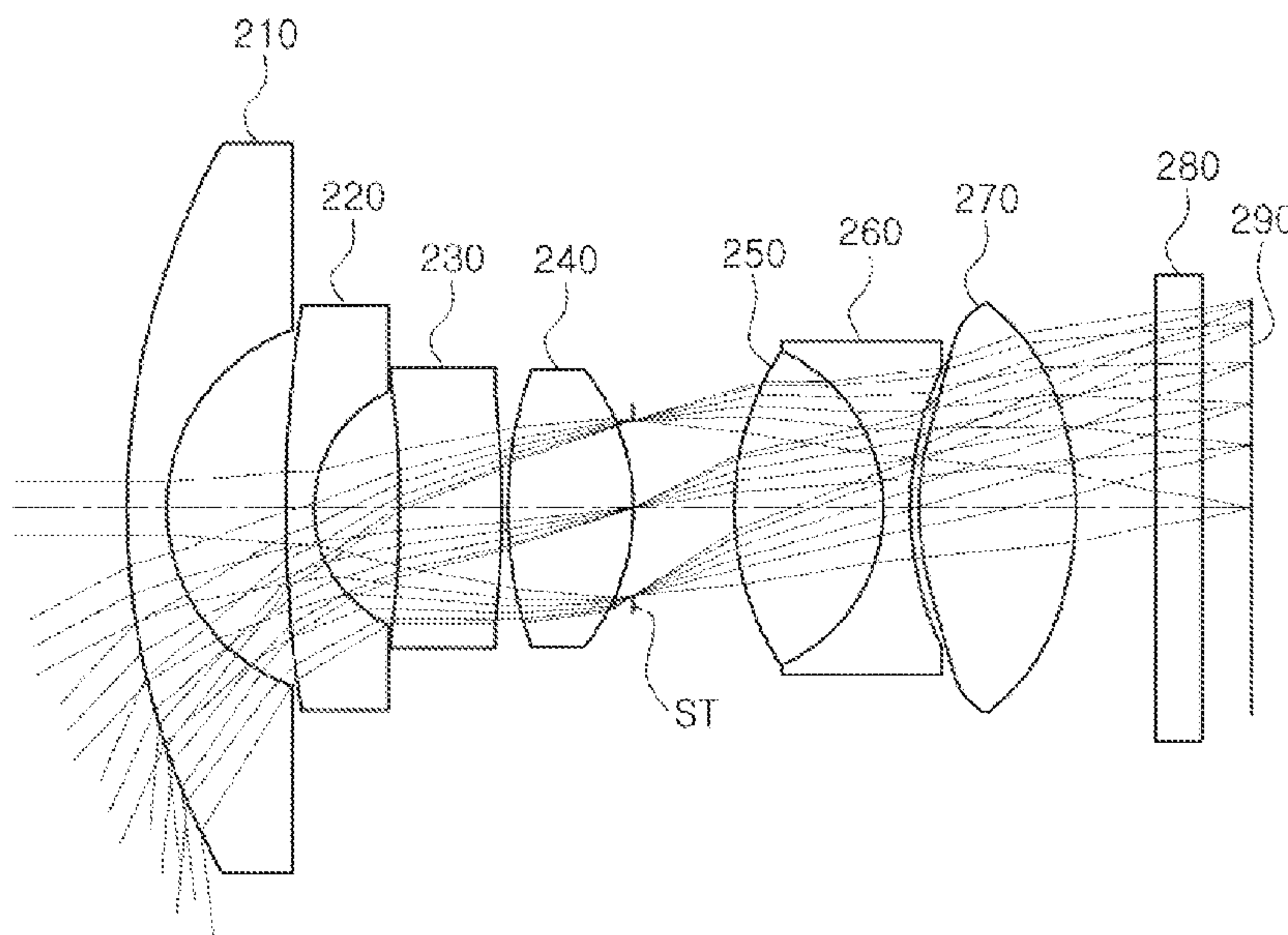
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(57) **ABSTRACT**

An optical imaging system includes a first lens having  
negative refractive power, a second lens having negative  
refractive power, a third lens, a fourth lens, a fifth lens, a  
sixth lens, and a seventh lens. The first to seventh lenses are  
sequentially disposed from an object side toward an image  
side. The third lens and the seventh lens are formed of  
plastic, and the first lens, the second lens, the fourth lens, the  
fifth lens, and the sixth lens are formed of glass.

**18 Claims, 4 Drawing Sheets**



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USPC .....	359/708, 713, 714, 715, 755, 754, 657				
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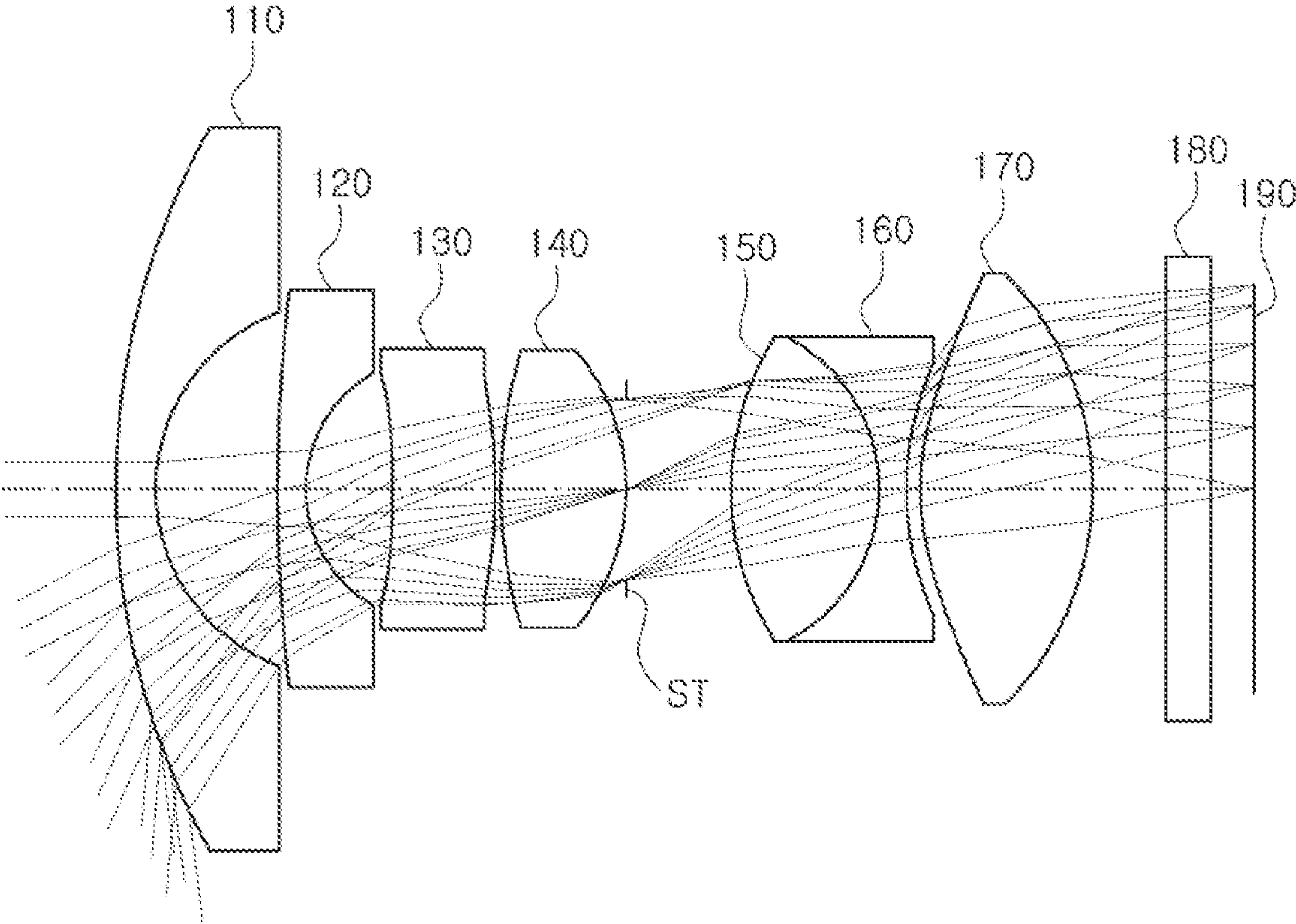


FIG. 1



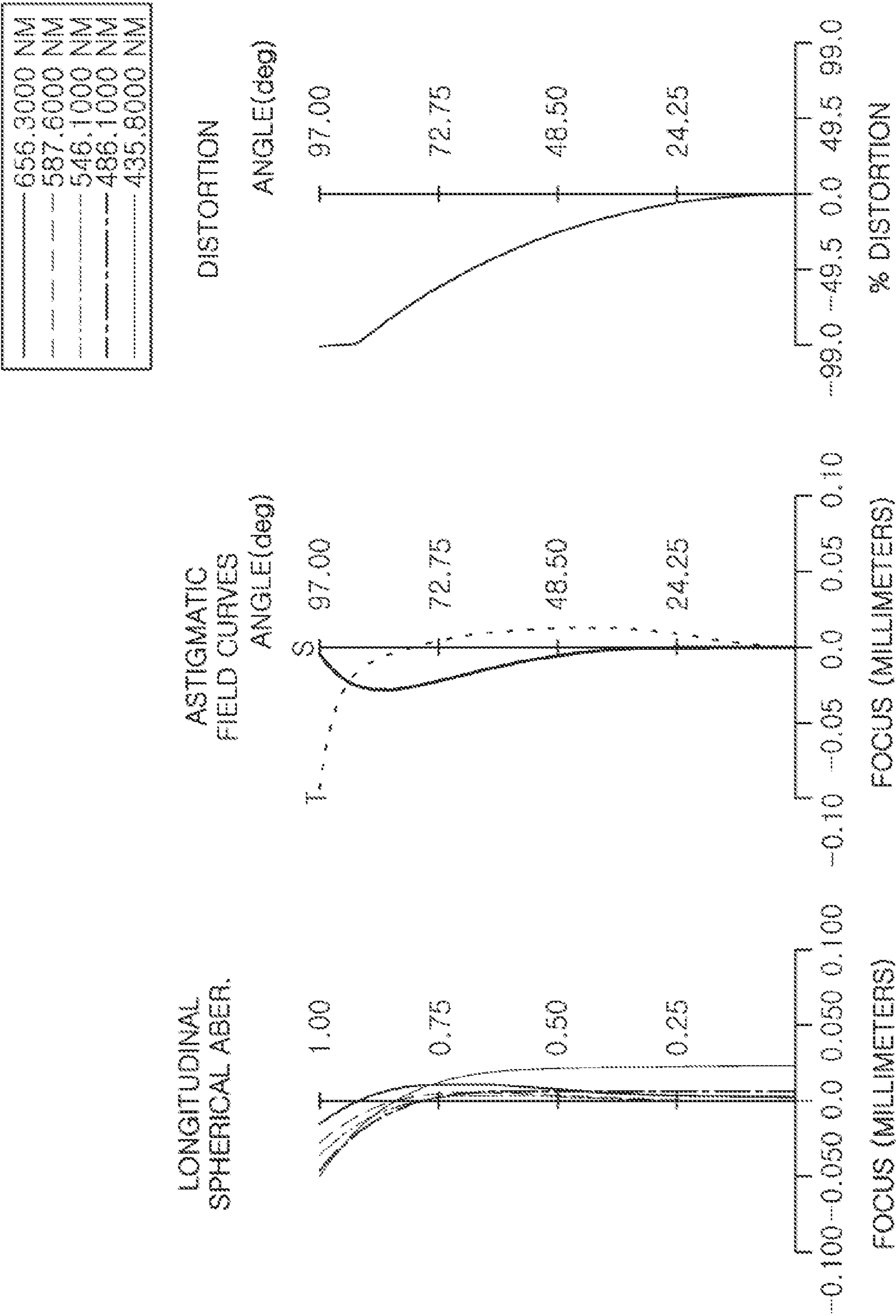


FIG. 2

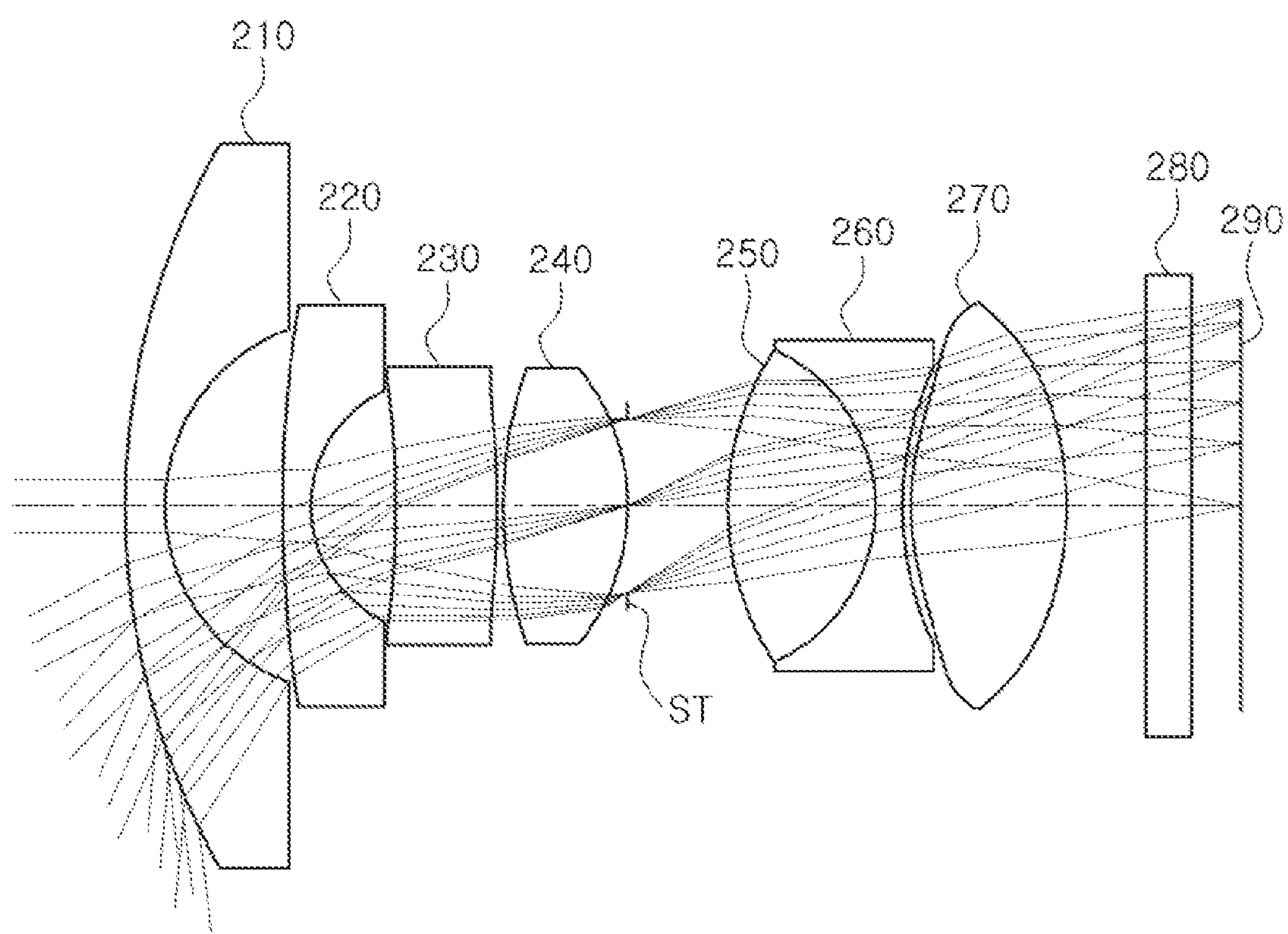


FIG. 3

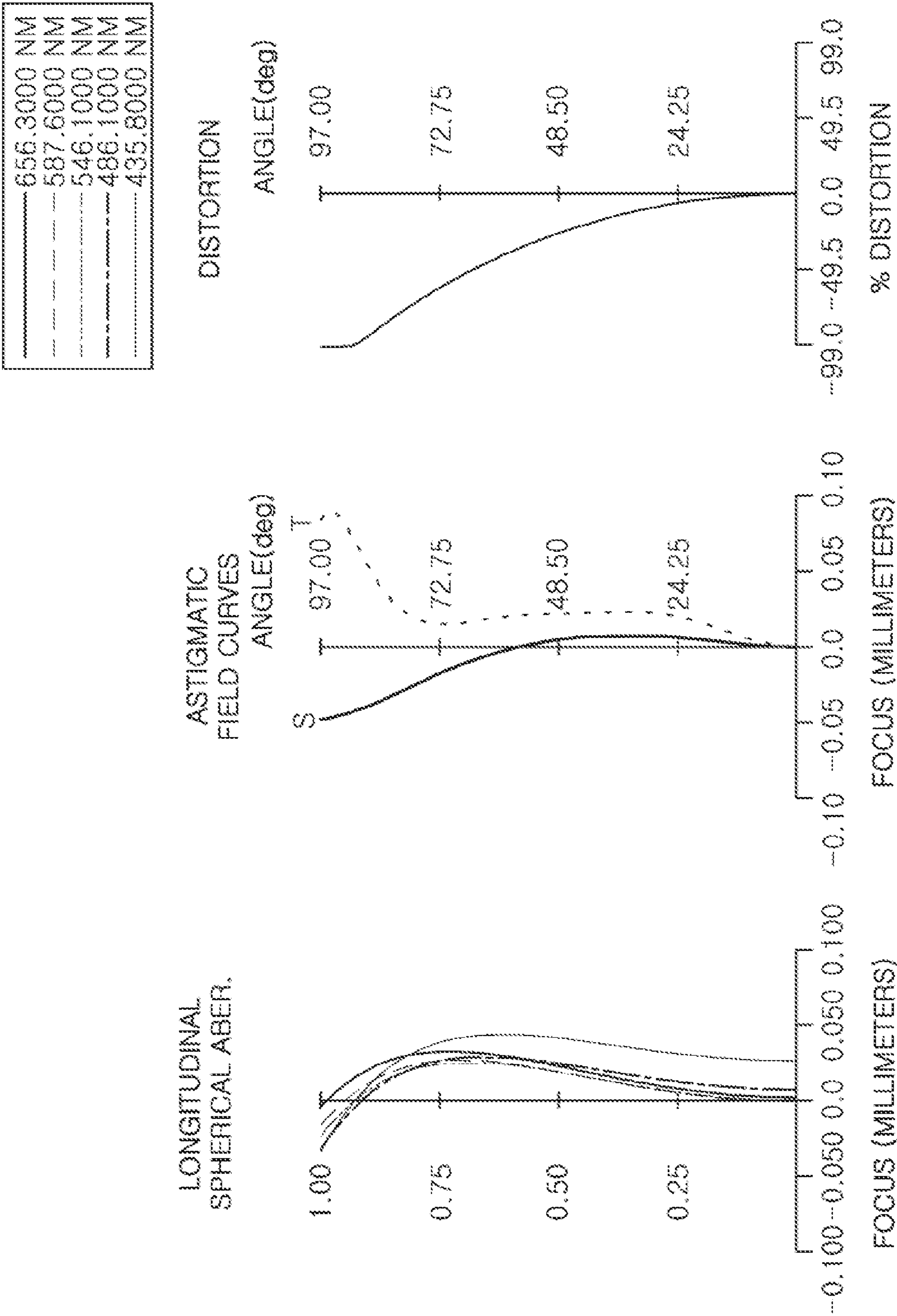


FIG. 4



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## OPTICAL IMAGING SYSTEM

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 16/108,599 filed on Aug. 22, 2018, now U.S. Pat. No. 11,448,857, which claims the benefit under 35 USC 119(a) of Korean Patent Application No. 10-201 7-01 55623 filed on Nov. 21, 2017, in the Korean Intellectual Property Office, the entire disclosures of which are incorporated herein by reference for all purposes.

## BACKGROUND

## 1. Field

This application relates to an optical imaging system.

## 2. Description of the Background

In general, camera modules are mounted in mobile communications terminals, computers, vehicles, and the like, enabling the capturing of images.

In accordance with the trend for slimmer mobile communications terminals, such camera modules have been required to have a small size and high image quality.

Meanwhile, a camera module for a vehicle has also been required to have a small size and high image quality to not obstruct a driver's visual field and spoil a vehicle appearance.

Particularly, a camera used in a rearview mirror of a vehicle should be able to capture a clear image to secure a rear visual field during driving of the vehicle, and is thus required to have high image quality.

In addition, a camera used in a vehicle should be able to clearly capture an image of an object, even at night when illumination is low, and thus requires a lens system that has a small size and which may capture an image in both of a visible wavelength region and a near infrared region.

The above information is presented as background information only to assist with an understanding of the present disclosure. No determination has been made, and no assertion is made, as to whether any of the above might be applicable as prior art with regard to the disclosure.

## SUMMARY

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

In one general aspect, an optical imaging system includes a first lens having negative refractive power, a second lens having negative refractive power, a third lens, a fourth lens, a fifth lens, a sixth lens, and a seventh lens. The first to seventh lenses are sequentially disposed from an object side toward an image side, the third lens and the seventh lens are formed of plastic, and the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens are formed of glass.

The object-side surfaces and image-side surfaces of the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens may be spherical surfaces, and object-side

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surfaces and image-side surfaces of the third lens and the seventh lens may be aspherical surfaces.

The third lens and the seventh lens may be formed of plastic having the same optical characteristics as each other.

The fifth lens and the sixth lens may be formed of glass having different optical characteristics from each other.

The fifth lens and the sixth lens may be cemented to each other.

The optical imaging system may further include a stop disposed between the fourth lens and the fifth lens.

In the optical imaging system TTL is a distance from an object-side surface of the first lens to an imaging plane of an image sensor, IMGH is a half of a diagonal length of the imaging plane of the image sensor, and  $TTL/(2 \cdot IMGH)$  may be less than 3.05.

In the optical imaging system R5 is a radius of curvature of an object-side surface of the third lens, f is an overall focal length of the optical imaging system including the first lens to the seventh lens, and  $R5/f$  may be greater than -15.0 and less than -5.0.

In the optical imaging system f3 is a focal length of the third lens and  $f/f3$  may be greater than 0.02 and less than 0.08.

In the optical imaging system f7 is a focal length of the seventh lens and  $f/f7$  may be greater than 0.4 and less than 0.48.

In the optical imaging system n3 is a refractive index of the third lens and n3 may be less than 1.535.

In the optical imaging system n7 is a refractive index of the seventh lens and n7 may be less than 1.535.

In the optical imaging system R1 is a radius of curvature of an object-side surface of the first lens, R2 is a radius of curvature of an image-side surface of the first lens, and  $R1/R2$  may be greater than 3.5.

In the optical imaging system R3 is a radius of curvature of an object-side surface of the second lens, R4 is a radius of curvature of an image-side surface of the second lens, and  $R3/R4$  may be greater than 10.

In another general aspect, an optical imaging system includes a first lens having negative refractive power and having a meniscus shape, of which an object-side surface is convex, a second lens having negative refractive power and having a meniscus shape, of which an object-side surface is convex, a third lens, a fourth lens, a fifth lens, a sixth lens, and a seventh lens. The first to seventh lenses are sequentially disposed from an object side toward an image side. The third lens and the seventh lens are formed of plastic. The first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens are formed of glass, and an image-side surface of the fifth lens and an object-side surface of the sixth lens are cemented to each other.

The third lens and the seventh lens may each have positive refractive power.

The third lens may have a concave object-side surface and a convex image-side surface, and the fourth lens and the seventh lens may each have convex object-side and image-side surfaces.

Other features and aspects will be apparent from the following detailed description, the drawings, and the claims.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a view illustrating a first example of an optical imaging system.

FIG. 2 illustrates examples of curves representing aberration characteristics of the optical imaging system illustrated in FIG. 1.



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FIG. 3 is a view illustrating a second example of an optical imaging system.

FIG. 4 illustrates examples of curves representing aberration characteristics of the optical imaging system illustrated in FIG. 3.

Throughout the drawings and the detailed description, the same reference numerals refer to the same elements. The drawings may not be to scale, and the relative size, proportions, and depiction of elements in the drawings may be exaggerated for clarity, illustration, and convenience.

## DETAILED DESCRIPTION

The following detailed description is provided to assist the reader in gaining a comprehensive understanding of the methods, apparatuses, and/or systems described herein. However, various changes, modifications, and equivalents of the methods, apparatuses, and/or systems described herein will be apparent after an understanding of the disclosure of this application. For example, the sequences of operations described herein are merely examples, and are not limited to those set forth herein, but may be changed as will be apparent after an understanding of the disclosure of this application, with the exception of operations necessarily occurring in a certain order. Also, descriptions of features that are known in the art may be omitted for increased clarity and conciseness.

The features described herein may be embodied in different forms, and are not to be construed as being limited to the examples described herein. Rather, the examples described herein have been provided merely to illustrate some of the many possible ways of implementing the methods, apparatuses, and/or systems described herein that will be apparent after an understanding of the disclosure of this application.

In the drawings, the thicknesses, sizes, and shapes of lenses have been slightly exaggerated for convenience of explanation. Particularly, the shapes of spherical surfaces or aspherical surfaces illustrated in the drawings are illustrated by way of example. That is, the shapes of the spherical surfaces or the aspherical surfaces are not limited to those illustrated in the drawings.

In this application, a first lens refers to a lens closest to an object, while a seventh lens refers to a lens closest to an image sensor.

In addition, a first surface of each lens refers to a surface thereof closest to an object side (or an object-side surface) and a second surface of each lens refers to a surface thereof closest to an image side (or an image-side surface). Further, all numerical values of radii of curvature and thicknesses of lenses, image heights (ImgH, a half of a diagonal length of an imaging plane of the image sensor), and the like, are indicated by millimeters (mm), and a field of view (FOV) of an optical imaging system is indicated by degrees.

Further, in a description for a shape of each of the lenses, the meaning that one surface of a lens is convex is that a paraxial region portion of a corresponding surface is convex, and the meaning that one surface of a lens is concave is that a paraxial region portion of a corresponding surface is concave. Therefore, although it is described that one surface of a lens is convex, an edge portion of the lens may be concave. Likewise, although it is described that one surface of a lens is concave, an edge portion of the lens may be convex.

A paraxial region refers to a very narrow region in the vicinity of an optical axis.

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An aspect of the present disclosure provides an optical imaging system in which an aberration improvement effect may be increased, a high level of resolution may be implemented, imaging may be performed even in an environment in which illumination is low, and a deviation in resolution may be suppressed even over a wide change in temperature.

An optical imaging system in the examples described herein may include seven lenses.

For example, the optical imaging system may include a first lens, a second lens, a third lens, a fourth lens, a fifth lens, a sixth lens, and a seventh lens sequentially disposed from the object side.

However, the optical imaging system is not limited to only including the seven lenses, but may further include other components, if necessary.

For example, the optical imaging system may further include an image sensor configured to convert an image of a subject incident on the image sensor into an electrical signal. The image sensor may be configured to capture an image of an object in a near infrared region as well as a visible light region.

In addition, the optical imaging system may further include a stop configured to control an amount of light. For example, the stop may be disposed between the fourth and fifth lenses.

In the optical imaging system in the examples described herein, some of the first to seventh lenses may be formed of plastic, and the others thereof may be formed of glass. In addition, the lenses formed of glass may have optical characteristics different from those of the lenses formed of plastic.

For example, the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens may be formed of glass, and the third lens and the seventh lens may be formed of plastic.

In addition, in the optical imaging system in the examples described herein, some of the first to seventh lenses may be aspherical lenses, and the others thereof may be spherical lenses.

As an example, first surfaces and second surfaces of the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens may be spherical surfaces, and first surfaces and second surfaces of the third lens and the seventh lens may be aspherical surfaces.

The aspherical surfaces of the third lens and the seventh lens may be represented by the following Equation 1:

$$Z = \frac{cY^2}{1 + \sqrt{1 - (1 + K)c^2 - Y^2}} + AY^4 + BY^6 + CY^8 + DY^{10} + EY^{12} + FY^{14} + \dots \quad (1)$$

In Equation 1,  $c$  is a curvature (an inverse of a radius of curvature) of a lens,  $K$  is a conic constant, and  $Y$  is a distance from a certain point on an aspherical surface of the lens to an optical axis in a direction perpendicular to the optical axis. In addition, constants  $A$  to  $F$  are aspherical coefficients. In addition,  $Z$  is a distance between the certain point on the aspherical surface of the lens at the distance  $Y$  and a tangential plane meeting the apex of the aspherical surface of the lens.

The optical imaging system including the first to seventh lenses may have negative refractive power/negative refractive power/positive refractive power/positive refractive



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power/positive refractive power/negative refractive power/positive refractive power sequentially from the object side.

The optical imaging system in the examples described herein may satisfy the following Conditional Expressions 2 through 9:

$$TTL/(2*IMGH)<3.05 \quad (2)$$

$$-15.0<R5/f<-5.0 \quad (3)$$

$$0.02<f/f3<0.08 \quad (4)$$

$$0.4<f/f7<0.48 \quad (5)$$

$$n3<1.535 \quad (6)$$

$$n7<1.535 \quad (7)$$

$$R1/R2>3.5 \quad (8)$$

$$R3/R4>10 \quad (9)$$

In the above Conditional Expressions 2 through 9, TTL is a distance from an object-side surface of the first lens to the imaging plane of the image sensor, IMGH is a half of a diagonal length of the imaging plane of the image sensor, R5 is a radius of curvature of an object-side surface of the third lens, f is an overall focal length of the optical imaging system, f3 is a focal length of the third lens, f7 is a focal length of the seventh lens, n3 is a refractive index of the third lens, n7 is a refractive index of the seventh lens, R1 is a radius of curvature of an object-side surface of the first lens, R2 is a radius of curvature of an image-side surface of the first lens, R3 is a radius of curvature of an object-side surface of the second lens, and R4 is a radius of curvature of an image-side surface of the second lens.

Next, the first to seventh lenses constituting the optical imaging system in some examples will be described.

The first lens may have negative refractive power. In addition, the first lens may have a meniscus shape, of which an object-side surface is convex. In detail, a first surface of the first lens may be convex in the paraxial region, and a second surface thereof may be concave in the paraxial region.

Both surfaces of the first lens may be spherical surfaces.

The second lens may have negative refractive power. In addition, the second lens may have a meniscus shape, of which an object-side surface is convex. In detail, a first surface of the second lens may be convex in the paraxial region, and a second surface thereof may be concave in the paraxial region.

Both surfaces of the second lens may be spherical surfaces.

The third lens may have positive refractive power. In addition, the third lens may have a meniscus shape of which an image-side surface is convex. In detail, a first surface of the third lens may be concave in the paraxial region, and a second surface thereof may be convex in the paraxial region.

Both surfaces of the third lens may be aspherical surfaces.

The fourth lens may have positive refractive power. In addition, both surfaces of the fourth lens may be convex. In detail, first and second surfaces of the fourth lens may be convex in the paraxial region.

Both surfaces of the fourth lens may be spherical surfaces.

The fifth lens may have positive refractive power. In addition, both surfaces of the fifth lens may be convex. In detail, first and second surfaces of the fifth lens may be convex in the paraxial region.

Both surfaces of the fifth lens may be spherical surfaces.

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The sixth lens may have negative refractive power. In addition, both surfaces of the sixth lens may be concave. In detail, first and second surfaces of the sixth lens may be concave in the paraxial region.

Both surfaces of the sixth lens may be spherical surfaces.

Meanwhile, the fifth lens and the sixth lens may be configured as a cemented lens. As an example, an image-side surface of the fifth lens and an object-side surface of the sixth lens may be cemented to each other.

The seventh lens may have positive refractive power. In addition, both surfaces of the seventh lens may be convex. In detail, first and second surfaces of the seventh lens may be convex in the paraxial region.

Both surfaces of the seventh lens may be aspherical surfaces.

In the optical imaging system configured as described above, a plurality of lenses may perform an aberration correction function to thus increase aberration improvement performance.

In addition, the optical imaging system may have an f-number (Fno) (a constant indicating brightness of the optical imaging system) of 2.4 or less to thus clearly capture an image of an object even in an environment in which illumination is low.

In addition, the optical imaging system may clearly capture the image of the object in both of a visible light region and a near infrared region.

Further, in the optical imaging system in some of the examples described herein, the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens may be configured as spherical lenses to thus reduce costs for manufacturing the optical imaging system.

In addition, in the optical imaging system in some of the examples described herein, since the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens are formed of glass having a relatively small coefficient of thermal expansion and the third lens and the seventh lens are formed of plastic, a constant resolution may be maintained even over a temperature range of about  $-40^{\circ}\text{C}$ . to about  $80^{\circ}\text{C}$ . Therefore, the optical imaging system in some of the examples described herein may implement a high level of resolution even in an environment in which a temperature changes over a wide range.

A housing in which the first lens to the seventh lens are disposed may be formed of plastic, and the housing may shrink or expand according to a change in temperature of the surrounding environment. Therefore, a distance between the seventh lens and the image sensor may be changed by the deformation of the housing according to the change in temperature, which may result in a problem that a focus does not converge properly.

However, in the optical imaging system in some of the examples described herein, since the third lens and the seventh lens are formed of plastic, the third lens and the seventh lens may shrink or expand according to the change in temperature of the surrounding environment.

Therefore, by designing an amount of deformation of the third lens and the seventh lens in consideration of an amount of shape deformation of the housing according to the change in temperature, a focus position may not be changed even in a case in which the temperature is changed.

That is, the optical imaging system in some of the examples described herein may be configured so that a variation of the distance between the seventh lens and the image sensor according to the change in temperature corresponds to a variation of the focus position according to the change in temperature.



An optical imaging system according to a first example disclosed herein will be described with reference to FIGS. 1 and 2.

The optical imaging system according to the first example may include an optical system including a first lens **110**, a second lens **120**, a third lens **130**, a fourth lens **140**, a fifth lens **150**, a sixth lens **160**, and a seventh lens **170**, and may further include a stop ST, an optical filter **180**, and an image sensor **190**.

Lens characteristics (radii of curvature, thicknesses of lenses or distances between the lenses, refractive indices, and Abbe numbers) of each lens are shown in Table 1.

TABLE 1

f = 2.24, Fno = 2.32, FOV = 194°					
Surface No		Radius of Curvature	Thickness or Distance		
Object		Infinity	Infinity	Refractive index	Abbe Number
1	First Lens	13	0.71.7725		49.6
2		3.3	2.1356		
3	Second Lens	28.8197	0.5	1.5891	61.2
4		2.3418	1.5235		
5*	Third Lens	-16.5	1.8	1.5311	55.7
6*		-9.5605	0.1		
7	Fourth Lens	8.4557	2.2	1.5174	52.1
8		-3.8111	0		
9	Stop	Infinity	1.8487		
10	Fifth Lens	5.0173	2.6	1.5891	61.2
11	Sixth Lens	-3	0.48	1.8051	25.4
12		5.3655	0.2453		
13*	Seventh Lens	4.371	3.0212	1.5311	55.7
14*		-5.3017	1.2788		
15	Optical Filter	Infinity	0.8	1.5167	64.1
16		Infinity	0.7625		
17	imaging Plane	Infinity	0		

In surface numbers of Table 1, the notation \* indicates an aspherical surface.

In the first example, the first lens **110** may have negative refractive power, and a first surface thereof may be convex in the paraxial region and a second surface thereof may be concave in the paraxial region.

The second lens **120** may have negative refractive power, and a first surface thereof may be convex in a paraxial region and a second surface thereof may be concave in the paraxial region.

The third lens **130** may have positive refractive power, and a first surface thereof may be concave in the paraxial region and a second surface thereof may be convex in the paraxial region.

The fourth lens **140** may have positive refractive power, and a first surface and a second surface thereof may be convex in the paraxial region.

The fifth lens **150** may have positive refractive power, and a first surface and a second surface thereof may be convex in the paraxial region.

The sixth lens **160** may have negative refractive power, and a first surface and a second surface thereof may be concave in the paraxial region.

The seventh lens **170** may have positive refractive power, and a first surface and a second surface thereof may be convex in the paraxial region.

Meanwhile, respective surfaces of the third lens **130** and the seventh lens **170** may have aspherical coefficients as illustrated in Table 2.

TABLE 2

Surface No.	K	A	B	C	D
5	-0.01028	-0.00475	0.000166	-9.8E-05	1.12E-05
6	-0.18758	-0.00073	0.000548	-0.00011	2.4E-05
13	-0.78800	-0.00539	0.000305	-1.3E-05	2.65E-07
14	-5.95155	-0.00404	0.00019	-9.1E-06	6.75E-08

In addition, the first lens **110**, the second lens **120**, the fourth lens **140**, the fifth lens **150**, and the sixth lens **160** may be spherical lenses and may be formed of glass. The third

lens **130** and the seventh lens **170** may be aspherical lenses and may be formed of plastic.

In addition, the third lens **130** and the seventh lens **170** may be formed of plastic having the same optical characteristics as each other.

Meanwhile, the fifth lens **150** and the sixth lens **160** may be configured as a cemented lens. That is, the fifth lens **150** and the sixth lens **160** may be cemented (bonded) to each other. For example, the image-side surface of the fifth lens **150** may be cemented to the object-side surface of the sixth lens **160**. The fifth lens **150** and the sixth lens **160** may be formed of glass having different optical characteristics from each other.

The fifth lens **150** and the sixth lens **160** formed of glass having different optical characteristics may be configured as a cemented lens to thus improve chromatic aberration correction performance.

In addition, the stop ST may be disposed in front of the cemented lens. As an example, the stop ST may be disposed between the fourth lens **140** and the fifth lens **150**.

In addition, the optical imaging system configured as described above may have aberration characteristics illustrated in FIG. 2.

An optical imaging system according to a second example disclosed herein will be described with reference to FIGS. 3 and 4.

The optical imaging system according to the second example may include an optical system including a first lens **210**, a second lens **220**, a third lens **230**, a fourth lens **240**, a fifth lens **250**, a sixth lens **260**, and a seventh lens **270**, and may further include a stop ST, an optical filter **280**, and an image sensor **290**.

Lens characteristics (radii of curvature, thicknesses of lenses or distances between the lenses, refractive indices, and Abbe numbers) of each lens are shown in Table 3.

TABLE 3

f = 2.26, Fno = 2.39, FOV = 194°					
Surface No.		Radius of Curvature	Thickness or Distance	Refractive Index	Abbe Number
Object		Infinity	Infinity		
1	First Lens	13	0.7	1.7725	49.6
2		3.3	2.0693		
3	Second Lens	22.5039	0.5	1.5891	61.2
4		2.2340	1.4852		
5*	Third Lens	-27.6196	1.8	1.5311	55.7
6*		-14.0930	0.1		
7	Fourth Lens	7.3398	2.2	1.5174	52.1
8		-3.8150	0		
9	Stop	Infinity	1.7642		
10	Fifth Lens	5.0089	2.6	1.5891	61.2
11	Sixth Lens	-3	0.48	1.8051	25.4
12		5.7104	0.1474		
13*	Seventh Lens	4.4845	2.7390	1.5311	55.7
14*		-5.8624	1.4043		
15	Optical Filter	Infinity	0.8	1.5167	64.1
16		Infinity	0.8728		
17	Imaging Plane	Infinity	0		

In surface numbers of Table 3, the notation \* indicates an aspherical surface.

In the second example, the first lens **210** may have negative refractive power, and a first surface thereof may be convex in the paraxial region and a second surface thereof may be concave in the paraxial region.

The second lens **220** may have negative refractive power, and a first surface thereof may be convex in a paraxial region and a second surface thereof may be concave in the paraxial region.

The third lens **230** may have positive refractive power, and a first surface thereof may be concave in the paraxial region and a second surface thereof may be convex in the paraxial region.

The fourth lens **240** may have positive refractive power, and a first surface and a second surface thereof may be convex in the paraxial region.

The fifth lens **250** may have positive refractive power, and a first surface and a second surface thereof may be convex in the paraxial region.

The sixth lens **260** may have negative refractive power, and a first surface and a second surface thereof may be concave in the paraxial region.

The seventh lens **270** may have positive refractive power, and a first surface and a second surface thereof may be convex in the paraxial region.

Meanwhile, respective first and second surfaces of the third lens **230** and the seventh lens **270** may have aspherical coefficients as illustrated in Table 4.

TABLE 4

Surface No.	K	A	B	C	D
5	94.32793	-0.00277	0.000518	-0.00021	3.60E-05
6	6.676489	0.000536	0.000343	-6.72E-05	1.84E-05
13	-1.34768	-0.00615	0.000573	-9.07E-05	6.00E-06
14	-14.2459	-0.00876	0.000907	-8.55E-05	2.68E-06

In addition, the first lens **210**, the second lens **220**, the fourth lens **240**, the fifth lens **250**, and the sixth lens **260** may

be spherical lenses and may be formed of glass. The third lens **230** and the seventh lens **270** may be aspherical lenses and may be formed of plastic.

In addition, the third lens **230** and the seventh lens **270** may be formed of plastic having the same optical characteristics as each other.

Meanwhile, the fifth lens **250** and the sixth lens **260** may be configured as a cemented lens. The fifth lens **250** and the sixth lens **260** may be formed of glass having different optical characteristics from each other.

The fifth lens **250** and the sixth lens **260** formed of glass having different optical characteristics may be configured as the cemented lens to thus improve chromatic aberration correction performance.

In addition, the stop ST may be disposed in the front of the cemented lens. As an example, the stop ST may be disposed between the fourth lens **240** and the fifth lens **250**.

In addition, the optical imaging system configured as described above may have aberration characteristics illustrated in FIG. 4.

As set forth above, in the optical imaging systems in the examples disclosed herein, an aberration improvement effect may be increased, a high level of resolution may be implemented, imaging may be performed even in an environment in which illumination is low, and a deviation in resolution may be suppressed even over a wide change in temperature.

While this disclosure includes specific examples, it will be apparent after an understanding of the disclosure of this application that various changes in form and details may be made in these examples without departing from the spirit and scope of the claims and their equivalents. The examples described herein are to be considered in a descriptive sense

only, and not for purposes of limitation. Descriptions of features or aspects in each example are to be considered as



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being applicable to similar features or aspects in other examples. Suitable results may be achieved if the described techniques are performed in a different order, and/or if components in a described system, architecture, device, or circuit are combined in a different manner, and/or replaced or supplemented by other components or their equivalents. Therefore, the scope of the disclosure is defined not by the detailed description, but by the claims and their equivalents, and all variations within the scope of the claims and their equivalents are to be construed as being included in the disclosure.

What is claimed is:

1. An optical imaging system comprising:
  - a first lens comprising negative refractive power, and comprising a convex object-side surface;
  - a second lens comprising negative refractive power;
  - a third lens comprising positive refractive power, and comprising a concave object-side surface and a convex image-side surface;
  - a fourth lens comprising positive refractive power, and comprising a convex object-side surface and a convex image-side surface;
  - a fifth lens comprising positive refractive power, and comprising a convex object-side surface and a convex image-side surface;
  - a sixth lens comprising negative refractive power, and comprising a concave object-side surface and a concave image-side surface; and
  - a seventh lens comprising positive refractive power, wherein the optical imaging system comprises a total of seven lenses and the first to seventh lenses are sequentially disposed from an object side toward an image side such that the fifth lens is spaced apart from the fourth lens at an optical axis,
- wherein R5 is a radius of curvature of the object-side surface of the third lens, f is an overall focal length of the optical imaging system, and  $-15.0 < R5/f < -5.0$ , and wherein f3 is a focal length of the third lens, and  $0.02 < f/f3 < 0.08$ .
2. The optical imaging system of claim 1, wherein TTL is a distance from an object-side surface of the first lens to an imaging plane of an image sensor, IMGH is a half of a diagonal length of the imaging plane of the image sensor, and  $TTL/(2 \cdot IMGH) < 3.05$ .
3. The optical imaging system of claim 1, wherein the third lens and the seventh lens are formed of plastic, and wherein the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens are formed of glass.
4. The optical imaging system of claim 3, wherein object-side surfaces and image-side surfaces of the first lens, the second lens, the fourth lens, the fifth lens, and the sixth lens are spherical surfaces, and object-side surfaces and image-side surfaces of the third lens and the seventh lens are aspherical surfaces.
5. The optical imaging system of claim 1, wherein the third lens and the seventh lens are formed of plastic having the same optical characteristics as each other.
6. The optical imaging system of claim 5, wherein the fifth lens and the sixth lens are formed of glass having different optical characteristics from each other.
7. The optical imaging system of claim 6, wherein the fifth lens and the sixth lens are cemented to each other.
8. The optical imaging system of claim 1, further comprising a stop disposed between the fourth lens and the fifth lens.
9. The optical imaging system of claim 1, wherein f7 is a focal length of the seventh lens, and  $0.4 < f/f7 < 0.48$ .

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10. The optical imaging system of claim 1, wherein n3 is a refractive index of the third lens and  $n3 < 1.535$ .

11. The optical imaging system of claim 1, wherein n7 is a refractive index of the seventh lens and  $n7 < 1.535$ .

12. The optical imaging system of claim 1, wherein R1 is a radius of curvature of the object-side surface of the first lens, R2 is a radius of curvature of an image-side surface of the first lens, and  $R1/R2 > 3.5$ .

13. The optical imaging system of claim 1, wherein R3 is a radius of curvature of an object-side surface of the second lens, R4 is a radius of curvature of an image-side surface of the second lens, and  $R3/R4 > 10$ .

14. The optical imaging system of claim 1, wherein the first lens comprises a concave image-side surface.

15. The optical imaging system of claim 1, wherein the second lens comprises a convex object-side surface and a concave image-side surface.

16. The optical imaging system of claim 1, wherein the seventh lens comprises a convex object-side surface and a convex image-side surface.

17. An optical imaging system comprising:

- a first lens comprising negative refractive power, and comprising a convex object-side surface;
  - a second lens comprising negative refractive power;
  - a third lens comprising positive refractive power, and comprising a concave object-side surface and a convex image-side surface;
  - a fourth lens comprising positive refractive power, and comprising a convex object-side surface and a convex image-side surface;
  - a fifth lens comprising positive refractive power, and comprising a convex object-side surface and a convex image-side surface;
  - a sixth lens comprising negative refractive power, and comprising a concave object-side surface and a concave image-side surface; and
  - a seventh lens comprising positive refractive power, wherein the optical imaging system comprises a total of seven lenses and the first to seventh lenses are sequentially disposed from an object side toward an image side such that the fifth lens is spaced apart from the fourth lens at an optical axis,
- wherein R5 is a radius of curvature of the object-side surface of the third lens, f is an overall focal length of the optical imaging system, and  $-15.0 < R5/f < -5.0$ , and wherein n3 is a refractive index of the third lens and  $n3 < 1.535$ .

18. An optical imaging system comprising:

- a first lens comprising negative refractive power, and comprising a convex object-side surface;
- a second lens comprising negative refractive power;
- a third lens comprising positive refractive power, and comprising a concave object-side surface and a convex image-side surface;
- a fourth lens comprising positive refractive power, and comprising a convex object-side surface and a convex image-side surface;
- a fifth lens comprising positive refractive power, and comprising a convex object-side surface and a convex image-side surface;
- a sixth lens comprising negative refractive power, and comprising a concave object-side surface and a concave image-side surface; and
- a seventh lens comprising positive refractive power, wherein the optical imaging system comprises a total of seven lenses and the first to seventh lenses are sequentially disposed from an object side toward an image

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side such that the fifth lens is spaced apart from the fourth lens at an optical axis,  
wherein R5 is a radius of curvature of the object-side surface of the third lens, f is an overall focal length of the optical imaging system, and  $-15.0 < R5/f < -5.0$ , and 5  
wherein R3 is a radius of curvature of an object-side surface of the second lens, R4 is a radius of curvature of an image-side surface of the second lens, and  $R3/R4 > 10$ .

\* \* \* \* \*

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